UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

RIFC - LOCAL FLOODS

NORTH FORK OF OGDEN RIVER

and

WEST FACE OF BEN LOMOND

M—5123

U. S. GOVERNMENT PRINTING OFFICE

9—7417

LANDSLIDES AND SEDIMENTATION IN THE NORTH FORK OF OGDEN RIVER, MAY 1949

By A. R. Croft and John A. Adams, Jr.[1/]

SUMMARY

During May 17 and 18, 1949, rain storms together with heavy spring snow melt, produced serious floods, erosion, and landslides in the North Fork of Ogden River. The most seriously affected area consisted of about 10,000 acres lying between Ben Lomond and Willard Peak and draining eastward to the North Fork about 5 miles above Pineview dam.

Examination of the drainages during the period of high water immediately after the floods revealed the sources of the flood water to be: (1) seepage from the mineral mantle; (2) melted snow water falling directly into the channel systems; and (3) overland flow on bare soil where infiltration and storage capacity apparently had been reduced by destruction of vegetation, litter, and topsoil. Large quantities of sediment had been fed into the streams by landslides, by the enlargement of stream channels and by sheet erosion from areas where dense vegetation and litter had been greatly reduced or destroyed.

The landslides were a major cause of the deposition of about 50 acre feet of sediment into Pineview Reservoir during the high stream discharges of the storm period. This represents about four times the normal annual sediment production of this stream. Landslides were also responsible for large quantities of streambed desiments that will eventually reach the reservoir. Moreover, the vertical-walled gashes left in the soil mantle by the slides may be the focal point of serious future erosion and sediment production.

[1/] Forester (research) and Engineer (civil), Intermountain Forest and Range Experiment Station, Ogden, Utah.

LANDSLIDES AND SEDIMENTATION IN THE NORTHFORK OF THE OGDEN RIVER, MAY 1949

By A. R. Croft and John A. Adams Jr. [1/]

Introduction

During May 17 and 18, 1949, rain storms together with heavy spring snow melt produced serious floods, erosion, and landslides in the north fork of the Ogden River. The most seriously affected area consisted of about 10,000 acres comprising Chicken, Cobble, Cold, and Cutler Creek drainages. These watersheds are on the east slope of the Ben Lomond--Willard Peak divide, Chicken Creek, the southern most of the tributaries enters North Fork about 3 miles above Pineview reservoir.

Examination of the drainages during the period of high water immediately after the floods revealed that the snow cover was still deep on the upper reaches from about 8,000 feet elevation to the mountain crest at about 9,000 feet. Most of the snow was a remnant of the winter pack, but some was freshly fallen.

These early investigations also showed the sources of the flood water to be: (1) Seepage from the mineral mantle; (2) collection of melted snow water by the channel systems; and (3) overland flow on bare soil where infiltration capacity apparently had been reduced by destruction of vegetation, litter, and topsoil. Large quantities of sediment had been fed into the streams by topsoil erosion from areas where dense vegetation and litter had been greatly reduced or destroyed and by the deepening and widening of stream channels.

Another, and somewhat unusual, form of erosion consisted of landslips that left deep, vertical-walled gashes in the mountainsides. In some cases, thousands of tons of soil and soil material had slipped from steep slopes to stream channels.

These landslides were a major cause of sedimentation in Pineview reservoir during the high stream discharges of the storm period. They also furnished much of the sand, gravel, and rock that was temporarily deposited along the North Fork channel, much of which will eventually reach the reservoir. Moreover , the vertical-walled gashes left in the soil mantle by the slides may be the focal point of serious future erosion and sediment production. Indeed, some of these deep scars may, by headward erosion, form deep channels reaching to the ridgetops.

The purposes of this paper are to describe the landslides, suggest their causes, and report briefly on the resultant sedimentation during the floods.

Description of Landslides

The landslides varied in place of origin, size, and age. They were largest on the north-facing slopes in timber cover and smallest on south-facing slopes with brush cover. The largest slide observed, which occurred in Cold Creek drainage, left a raw, deep scar of several acres, and scattered mud, boulders, and timber over about 75 acres down a three-quarter-mile course to the channel. Here it made a log and boulder jam in the channel. The slides from south-facing slopes were usually rather small, mostly only a few feet deep.

The slopes were examined for evidence of previous landslides. Most of the slides, including the largest one, occurred during the May 17-18 rains but it was possible to identify a few older ones. The age of these was estimated at between 20 and 40 years by examination of vegetation existing on them.

A careful study of Cold Creek drainage, where most of the slides occurred, revealed no earlier slides in the mineral mantle. Had they taken place their evidences would have persisted for hundreds of years. It is believed, therefore, that landslides have been rare, if not entirely absent, in this drainage basin since the present mineral mantle developed on its slopes. The slides of the past 40 years, culminating in those of this spring, probably represent a new form of erosion, at least as far as the present mantle is concerned.

Possible Cause of Slides

Although the cause of the slides is not definitely known, the following hypothesis is presented as an explanation. The normal mantle and soil on the steep slopes of Cold Creek drainage have been accumulating for thousands of years. During this accumulation, vegetation--timber, woodland, brush, and herbaceous species, in composition much like the present stand--had grown on the steep slopes. Mile upon mile of roots, many very large and tough, have ramified through the mantle like a giant web and provided mechanical support to hold it in place. This stability has been maintained even though, over the years, the mantle has probably deepened by accretion of material from the rocky ridges above, and by disintegration of bedrock beneath. During this time slopes have been steepened by deepening of the channel due to stream action.

As the mantle became deeper and slopes steeper it is reasonable to assume that the potential for slipping increased and that in some places the mantle was kept in place at most critical seasons only by the mechanical support provided by the network of plant roots.

During the past 75 years this mechanical support to the mantle has been gradually lessened, chiefly by timber cutting and burning and to some extent by excessive livestock grazing. This progressive decadence of the vegetation and death and decay of root systems has left the mantle with less mechanical root support than it has had for many thousands of years in the past. With the mantle's root support weakened, water in the soil from heavy snow melts combined with rainfall increased the weight of the mantle beyond its load limit so that large parts of it gave way in the form of landslides.

Sedimentation in Pineview Reservoir

The soil, soil material, rocks, and boulders coming from slides and channel degradation in upper Cold Canyon as well as in adjacent canyons were carried downstream by the flood. The larger rocks and boulders were dropped along the channel of Cold Canyon in the stream reach a mile or so above the mouth. The cobbles, gravel, sands, and finer materials were generally carried farther downstream. Most of the gravels and sands were deposited in the North Fork channel in the reach from Liberty to the mouth of the stream in Pineview reservoir. Much of this material that was deposited along the stream channels no doubt will move on downstream during future floods and will ultimately come to rest in Pineview reservoir. The finer sands and silts in suspension, as well as some bed load material, were carried into Pineview reservoir,

and then deposited below the water storage line, thus reducing the capacity of the reservoir. Some of the finer silts carried in the flood flow density current appeared at the spillway of Pineview Dam, being indentified by their brownish-yellow color.

The exact amounts of material displaced by the flood and deposited downstream cannot be accurately determined. However, field measurements of channels, samples of the flood water in which quantities of sediment were determined, and previous related work in this area makes possible a comparison of the amount of material carried into the reservoir during this flood as compared to amounts in average years.

The quantity of suspended sediment going into Pineview reservoir was established from samples of the suspended sediment in the flood water. Observations indicate that prior to the rain of May 17-18, the North Fork was experiencing its normal spring snow melt rise. The water was high but relatively clear. According to local observers the North Fork became very muddy the morning of May 17. The flood peak from the rain occurred about 3:00 p.m., May 17. The stream continued to be muddy until May 25 and then cleared noticeably.

Random samples (taken in bottles) of the flood water May 17-18 on the main stem of the North Fork and flooding tributaries contained suspended sediment concentrate varying from 0.04 percent to 2.40 percent by volume. The samples along the North Fork averaged about 1 percent by volume. The volume weight of this sediment is about 62.5 pounds per cubic foot. Applying the above data to the total volume of water flowing from the North Fork between May 17 and 25 indicates that no

less than 50 acre feet of sediment was deposited in Pineview reservoir. Volume of water was determined from the discharge of Pineview reservoir, reservoir storage change, gaged inflow of South Fork, and estimated inflow of Spring Creek and Middle Fork.

The amount of sediment which has previously been deposited in Pineview reservoir was determined by the Flood Control Survey Division of the Intermountain Forest and Range Experiment Station in a study made in 1947. This study showed that the average yearly volume of sediment deposited amounted to 19 acre feet. Placing this volume on the watershed results in 0.06 acre feet per square mile of watershed per year (total watershed area is 310 square miles). The report indicated that the 63 square mile North Fork is more of a sediment contributor than the 193 square mile South Fork. The report also mentions that there were sediment deposits on the North Fork channel about two miles above the backwater of the reservoir.

Using the above data as a basis, the North Fork in the last 10 years has been producing approximately 12 acre feet of sediment per year. As much as 90 percent of this is estimated to have been produced furing the month of high spring flow.

From observations made in 1949 it appears that this flood carried at least from 5 to 10 times more suspended sediment into Pineview reservoir than has been deposited in the reservoir by average spring flows.

The amount of bed load material entering the reservoir during the flood is not known. Studies in other similar drainage areas indicate that bed load may be from 10 to 25 percent of the suspended load.

The sediment that was carried into the Pineview reservoir during the course of the flood is in itself a serious matter. Of greater concern is the still larger quantity of unstable bed load in the main stem of the North Fork, the unstable condition of the vertical-walled channel banks in the upper stream reaches, and the actively eroding condition of the mountain slopes. Unless the materials on these sediment s ource areas are stabilized it appears certain that Pineview reservoir will be subject to much greater sedimentation rates than have occurred since the reservoir was constructed. This threat to the useful life of such an important water project clearly points to the need for early action to install remedial measures on the damaged lands.

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION FOREST SERVICE
OGDEN, UTAH

To: Station and Region 4 Personnel 5/31/49

From: Reed W. Bailey, Director, By Geo. W. Craddock

Subject: RIFC - INT, LOCAL FLOODS, Willard Peak-Ben Lomond Area, 1949

Several damaging floods occurred north of Ogden, Utah during the period May 17 to 21. One group of floods occurred in streams that drain the west face of the Wasatch Mountains between the towns of Willard and North Ogden. Another group occurred on the east side of the mountain crest in the Mill, Cutler, Cold, Cobble, and Chicken Creek tributaries of the North Fork of Ogden River.

These floods provoked much public interest. It will be recalled that especially destructive mud-rock floods occurred in Willard Canyon and in several North Fork tributaries in the summer of 1923. The Forest Service determined that abuse of headwater lands was a major cause of those floods. A second flood occurred at Willard in the summer of 1936. After this event, the Willard watershed was closed to grazing and the flood source areas were contour-trenched and seeded to grass. No comparable action was taken to improve the North Fork watershed lands, though in the past year or two there has been much public interest in such a program. In view of these events, it is probably only natural that the Forest Service has been showered with inquiries as to (1) was man responsible for the recent floods? and (2) what are the prospects for controlling future floods?

These are critical questions and it is of great importance that we, as well as the public, be accurately informed. Accordingly, representatives of the Station, the Regional office, and the Cache National Forest have undertaken an inquiry into the situation. An over-all inspection of the area was made by plane. Parts of the Willard Canyon and the North Fork tributaries have been inspected on the ground. Further examinations are planned, but enough information has been gathered thus far to warrant some general conclusions for use in discussing the flood situation with the public.

The floods off the west face of the mountain range are believed to be essentially normal, though of greater magnitude than has been experienced for many years. Runoff in this area originated mainly on very steep, bare rock surfaces in the canyon headwaters. These are naturally barren slopes on which little, if any, soil has developed. Because these source areas had very low water storage capacity, water from rain and melted snow gathered in the channels in sufficient volume and with enough velocity to scour accumulated fill material and to generate flood flows. Discharges from these canyons reached their main peak on the morning of May 17 and then subsided rather rapidly.

Large alluvial fans of post-Bonneville age at the mouth of these canyons show that many floods have issued from them in the recent geologic past. They also indicate that floods can be expected in the future whenever the headwaters receive a relatively large amount of rain. Man, in other words, had nothing to do with the generation of floods in these canyons.

Though man did not start these floods, it is clear that his occupancy of the flood fans increased their severity after they left the canyon mouths. Diversion works in the creeks and runoff control ditches on the lower mountain slopes concentrated the flood waters. Extensive removal of the brush cover and clean cultivation of orchards on the sloping alluvial fans in recent years reduced the normal tendency for flood waters to spread over the fan. Instead, clearing the slopes for agriculture permitted concentration of runoff, deep gullying and an abnormal extension of the flood flows.

Investigations on control possibilities have not been completed for this area. It is clear, however, that control efforts must be confined to the flood fans rather than the headwater slopes. Possible remedial measures include water spreading works by mechanical and plant cover methods, channel works and catchment basins.

Willard Creek, which heads on the north-facing slope of Willard Peak then drains westward to the town of Willard, did not produce damaging runoff comparable to the discharges from the other west-facing tributaries that drain the mountain slope south of Willard. Much of the upper Willard basin was deeply filled with snow when the rains came. This mantle of snow and the soil under it evidently had sufficient storage capacity to absorb and hold most of the rain that fell. As a consequence, discharges occurred mostly as seepage flow at rates which were not excessive.

Floods developed in the east-slope area by reason of several contributing factors, some normal and some doubtless induced by man. Headwaters of these east drainages were logged many years ago and they have been burned and heavily grazed, at least since the turn of the century. As a result, many areas once covered with dense timber and brush are now essentially bare eroded surfaces.

It is conceded that there was an unusually large amount of rainfall and snow melt, and that steep slopes and high gradient channels are common. Rocky areas in the upper watershed reaches contributed some runoff but a good part of these were snow-covered which lessened their effect.

Flood waters in this area originated as seepage from very wet mantles and from overland flow due to saturated soil, or to loss of infiltration capacity on old logging roads and skid ways, burns, and overgrazed areas. The extent to which destruction of timber, brush, litter, and topsoil, contributed to these phenomena, especially to overland flow, is not known precisely. However, there was evidence on the ground that such areas did contribute substantial amounts of runoff. Overland flow quickly added water to channels to create surges that would not have occurred if more of the rain water could have sunk into the mantle. These peak flow surges provided enough energy to undercut the channel banks in many places and to cause large land slips at the channel edge on formerly stable slopes.

In Cold Canyon some land slips were found near ridge tops at considerable distance from channel banks. The occurrence of these slumps appeared to be due to weakened root systems as a result of fire and timber cutting.

The land slips almost invariably opened springs and permitted strong discharges of seepage flow to drain directly to channels and thus further augment the flood flow. Failure of the temporary dams formed by slumps apparently caused additional surges and additional undercuttings of channel banks, thus augmenting the debris load.

The extreme headwaters of the east-slope tributaries had a deep snow mantle at the time of the floods. These snow fields absorbed much of the rain and thus probably reduced the magnitude of the discharges to some extent.

These east-slope tributaries present a most difficult problem. Little, if anything, can be done to retard runoff from the naturally barren rock areas, so that some flood runoff can always be expected from those sources as in the past. Much runoff and debris can also be expected from the freshly ripped channels and land slumps during spring runoff even though heavy rains like those on May 17 and 18 do not occur. Moreover, heavily laden debris floods such as those that occurred in the summer of 1923, as a result of intense rainfall on dry bare soil surfaces are a definite possibility.

As bad as the conditions are, all possible measures should be taken to keep the situation from getting worse. This will require the elimination of grazing abuse, especially on the steep slopes; very tight fire control; the restoration of the greatest possible density of plant cover and litter; and supplemental soil stabilization by mechanical means. The prospects for trapping and stabilizing debris now on its way to Pineview Reservoir have not been investigated but should not be overlooked as part of the protection plan for this area.

Photos 1 - 20 inclusive, illustrate snow cover, watershed and channel conditions, and landslips in Cutler and Cold drainages taken on May 19, 1949.

Photo 1. The rocky south-facing slope of Upper Cutler drainage. Most of the mantle below the vertical cliff is rocky talus. (Photos 1 to 7 may be fitted together to make a panoramic view of the drainages whose headwaters are in the vicinity of Pyramid and Ben Lomond Peaks).

Photo 2. Pyramid Peak and the north headwater of Cutler drainage.

Photo 3. South headwater of Cutler drainage and Ben Lomond Peak on extreme left.

Photo 4. Cold Canyon--Cutler drainage divide and Ben Lomond Mountain.

Photo 7. Part of North Fork of Ogden River showing settlements of Liberty and Eden.

Photo 8. Log jam on snow in upper Cold Canyon drainage near snow line. Approximate elevation 8,500 ft.

Photo 9. Near snow line in head of Cold Canyon drainage. Above this point, the main drainage and practically all tributaries have from 2 to 6 feet of snow at channel bottoms.

Photo 10. Channel of Cold Canyon immediately below the falls. Large quantities of sediment are slipping into the stream channel as a result of channel deepening.

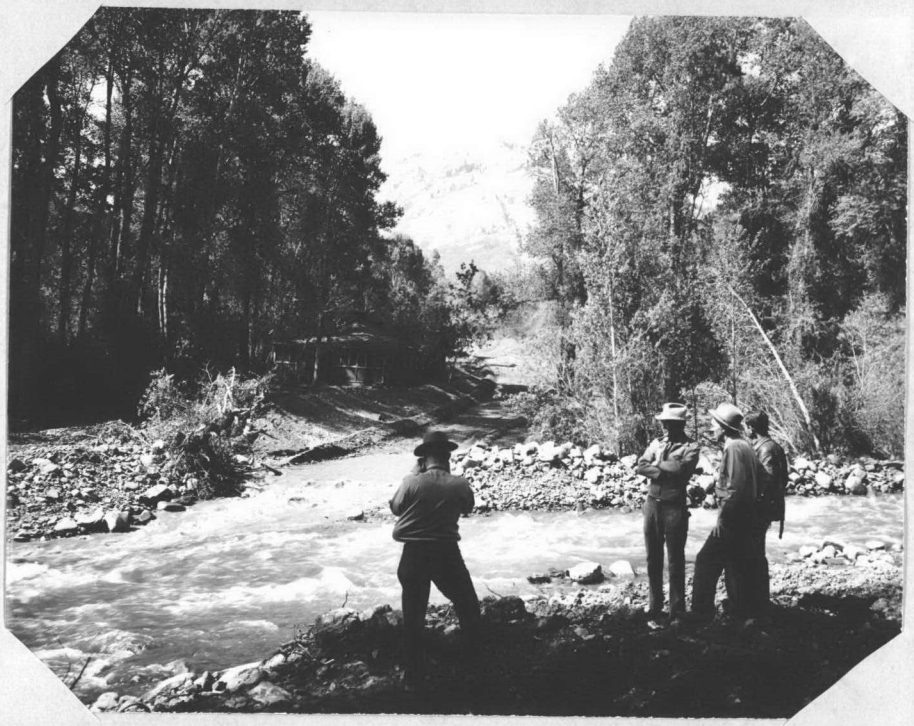


Photo 11. Newly cut channel of Cold Canyon where it joins North Fork Creek. Olsen summer home is on left. Prior to the flood of 5/17 and 18, 1949, the stream was carried by a 5 x 5 masonry rubble channel. The highest discharge through this channel since the flood of 8/13/23 was about 120 c.f.s. Data for this calculation were supplied by Harold Olsen, whose family has occupied the dwelling for many years. Discharge measurement made by G. W. Craddock on the afternoon of 5/17/49, indicate the discharge of about 280 c.f.s. Of this amount the rubble channel carried about 250 c.f.s. and about 30 c.f.s. were moving in the new channel to the right of the house. During the next few days the channel, as shown to the right of the house was deepened by a bulldozer so that it carried all the stream.

Photo 12. Badly deteriorated range on the lower north face slope of Cutler drainage.

left Howard E Peterson - INT. Station

Ted Coleman, USFS Washington Office

Photo 13. Gully made by surplus runoff from part of the area shown in photo No. 12. Because snow has probably been gone on most of this area for several weeks except for drifts overland flow of water was probably not due to saturated soil. It seems most reasonable to assume that the cause of overland flow was due to low infiltration capacity as a result of loss of topsoil and soil compaction.

Photo 14. One of the many snow drifts near the snow line in Cutler and Cold drainages. Surface runoff occur from the bare land in foreground. Ranger Anderson reports that most of these drifted spots have little if any perennial vegetation. It is probable, therefore, that absorption of rainfall and snow prevented serious runoff from such areas.

Photo 15. Channel below snow drift in photo No. 14. This channel has had no flowing water in it this spring. This suggests that rainfall was absorbed mostly by snow or if it was not absorbed that the rate of release of water by the snow was not in excess of the infiltration capacity of the soil.

Photo 16. Small landslip near snow line in Cold drainage. Considerable overland flow occur from the bare land area adjacent to the slip, presumably because of saturated soil. Overland flow passed under the snow to the stream which is covered in part by the snow in foreground. Clumps of vegetation are very heavily grazed. Many of the slopes directly above stream channels of Cold drainage are depleted of vegetation and topsoil as indicated in this photo.

Photo 17. Bad deterioration of vegetation and soil near stream channel in Cold drainage. Small landslip is also shown.

Photo 18. One of the slopes above stream channel in Cold drainage where vegetation and soil have undergone serious deterioration. This area produced considerable overland flow. Cold Creek is about 6 to 8 feet below the snow shown at right.

Photo 19. A seep (rock area in foreground) in Cold drainage. Overland flow from deteriorated drainage basin above, produced considerably more water to the channel than did the seep, according to comparative channel size.

Photo 20. One of the many landslips in Cold drainage. Other such slips many times larger than this one, were observed. Slips contributed very large quantities of sediment to the stream but it is believed their contribution of water to the main flow in Cold drainage was relatively small. It is probable that several of them dammed the creek completely, impounding water which when released, may have been responsible for some of the high discharges detected lower down in the channel. No evidence of such landslips of an earlier period was found. However, snow covered much of the upper watershed so that it could not be inspected for such phenomina. These slips will be given more careful study about June 1, when a second trip will be made into the Cutler and Cold drainages to obtain additional information in flood causes.

Photos 1 - 21 show snow cover, watershed conditions, and landslips in Cutler and Cold drainages on June 16, 1949.

Photos 1 - 6. Panoramic view of the heads of Cutler and Cold drainages. Comparison with the panoramic view of the same view taken on May 19, two days following the spring flood from the area. Gives an idea of the nature of the land surfacesthat were covered by snow when the floods came. 6-16-49.

Photo 7. The view northward in the south fork of Cutler drainage. Shrubs are heavily grazed, snowberry. Much of the top soil has been washed away. Practically all perennial grasses and herbs with the possible exception of geranium have been destroyed by heavy use. 6-16-49.

Photo 8. Burn in alpine fir in the south fork of Cutler drainage. Soil is badly eroded and gullied. On the steep slope in the background vegetation has been very seriously depleted and the woil, only a few inches deep in many places, has undergone serious erosion. 6-16-49.

Photo 9. Headquarters of a sheep operation in the south fork of Cutler drainage. Burning and excessive grazing have left the ground practically bare of perennial vegetation. 6-16-49.

Photo 10. View southward from cabin at sheep headquarters in south fork of Cutler drainage. 6-16-49.

Photo 11. Damaged vegetation and soil immediately south of cabin in Cutler drainage. 6-16-49.

Photo 12. Part of the south-facing slope of Cutler drainage. The white streaks are rock talus. This slope was bare of snow during the flood of May 17, 18, 19, 1949, but presumably the wet, rocky mantle permitted rainfall to pass through it rather quickly to stream channel. 6-16-49.

Photo 13 and 14. View southward near the head of Cold drainage. Burning and heavy grazing have severely damaged timber, perennial vegetation, and soil. 6-16-49.

Photo 15. View southward in the head of Cold drainage. Drifted snow covers many small areas for many weeks after surrounding land is bare. Such areas have been subject to grazing when plants were very immature and probably accounts for the fact that these areas now support mainly small annual plants. 6-16-49.

Photo 16. Landslip in a south branch of Cold drainage thousands of tons of wet soil and mantle material were carried into the main channel of Cold Creek by this slip. Vertical banks 30 to 40 feet high were exposed by the slide. 6-16-49

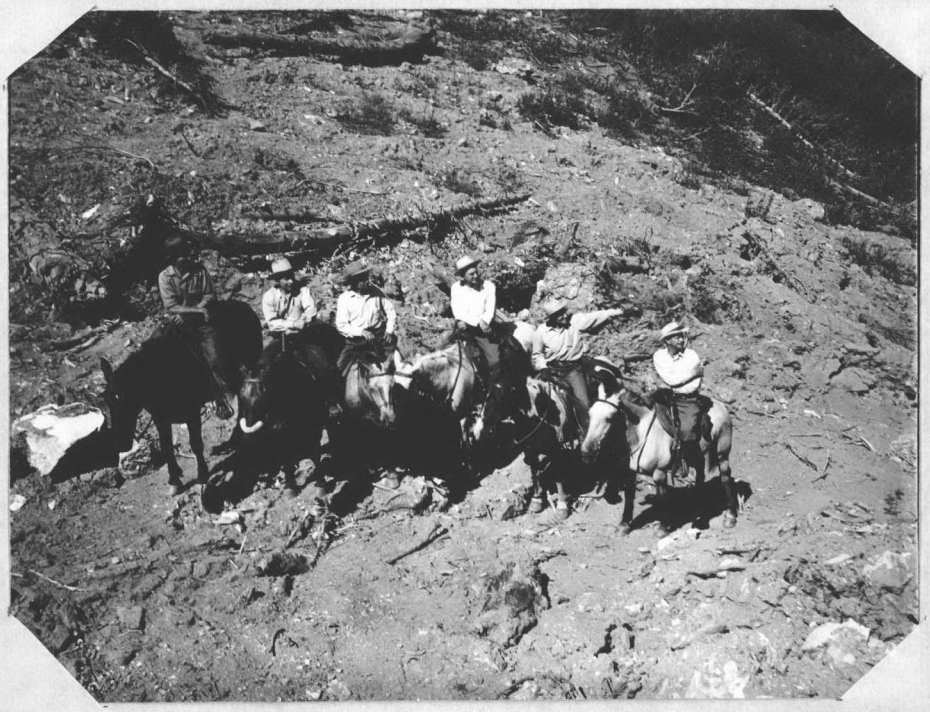
Photo 17. View of slide in Cold drainage shown in Photo 15 looking downstream. The main mass of debris in Cold Creek by the drainage at the right. By sweeping onto the ridge at the left the slide covered a small stand of aspen and brush. 6-16-49.

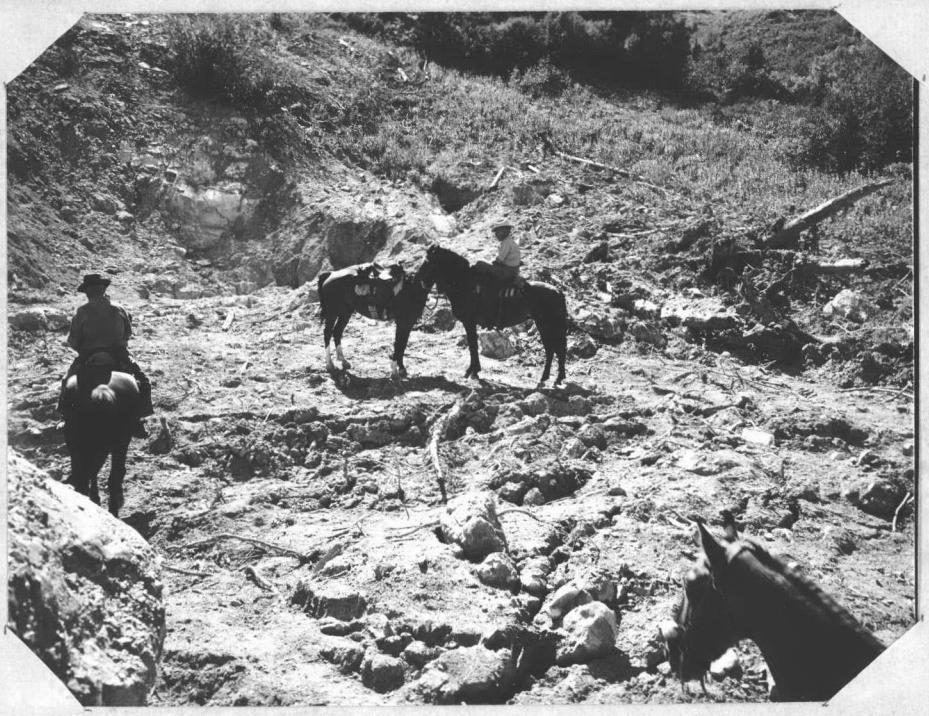
Photo 18. One of the numerous landslides from the south slope of Cold drainage. The hole left by the slip is about 25 feet deep. The slip apparently contributed a very large amount of sediment to Cold drainage, but only a relatively small amount of water. 6-16-49.

Photo 19. North-facing slope of Cold drainage showing landslips of various ages. The slides in the center, right foreground, and right background occurred in May 1949. At the left of the long slide may be seen another where the surface has been partly covered by young timber. None of the slides obviously appeared to be more than 30 or 40 years old. The deep gouges that such slips make in the mantle will probably persist for many thousands of years. The absence of such depressions suggest that slides of the magnitude of those of May 1949, have probably not been common to the area in recent geologic times. 6-16-49.

Photo 20 and 21. Burned timber on north-facing slope of Cold drainage. Loss of mechanical support provided by dense stands of timber is believed to be one of the factors responsible for the landslips which have occurred in Cold drainage. 6-16-49.

Photos 1 - 8 show some watershed conditions in Cutler and Cold drainages on August 30, 1949. These photographs were taken during an inspection trip of the watersheds by the Weber County Protective Organization. The group was made up of stockmen, farmers and water users, municiple officials and businessmen.





Photos 1 and 2. A few members of the Weber County Protective Organization party that inspected Cold and Cutler drainages on August 30, 1949. Above, Julian Hepler points out huge hole in the watershed made by landslide in Upper Cold drainage. Below, landslide sediment and edge of 100 pound boulder brought down by the slide.

Photos 3 and 4. Near the divide before Cutler and Cold drainages. Except for timber and brush patches, the ground is bare and all top soil has been lost by erosion.

Photos 5 and 6. Above, view from cabin in head of Cutler Creek to toward Ben Lomond. Here the soil is only a few inches deep and in some places it has been eroded to bedrock. Below, burned timber and bare soil show above cabin in Cutler drainage.

Photos 7 and 8. Above, sheep trails in Upper Cold drainage. Below, divide between Cold and Cutler drainages. Here hardly a square inch of ground could be found that didn't bear the imprint of sheep hoofs.